TEST AND DATA SUMMARY

Supplementary Radiant Panel Test Data

Data Transmittal No. ~~47~~ 48

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PROJECT TITLE: Hazardous Combustible Characteristics of Cabin Interior Materials, Project 510-001-11X

PURPOSE:

1. To update Report NA-68-30, Flaming and Self-Extinguishing Characteristics of Aircraft Cabin Interior Materials to include data on additional materials tested of particular interest to the formulation of new standards.

2. To present comparitive flame-spread index data from several different laboratories on the same materials using the Radiant Panel Test Apparatus.

BACKGROUND:

This report includes the results of flammability tests on a number of materials received subsequent to the completion of the test program on some 140 materials covered in Report NA-68-30. Based on the performance of these materials in the fire tests, recommendations were made at that time for improving the present regulations pertaining to interior materials. Fire testing of new materials were continued to reinforce these recommendations by (1) seeking to obtain additional evidence and, (2) as an encouragement to materials manufacturers to continue their R&D effort in this area. Most of the new materials investigated not only offered superior self-extinguishing properties but also demonstrated low flame-spread potential to a severe fire environment as well as hopefully low smoke and/or toxic gases emission. For the latter no requirements presently exist but have recently been considered for possible regulatory action. The materials selected in this report were accepted as practical replacements to the more conventional materials. Although, it has been possible to increase considerably the fire-resistance of many materials by addition of various chemical inhibitors (i.e. halogens, phosphorous and metal oxides), this simple solution does not alleviate the smoke problem or lead to any significant reduction in flame-spread index as obtained under the more severe test fire conditions.

The report also contains test data obtained by several independent laboratories on identical test specimens. The materials were selected by the Boeing Co. and furnished by this company to participating laboratories through NAFEC. These materials, especially the polycarbonates had proven especially difficult to test because of the excessive tendency to this plastic to melt and drip when exposed to radiant heat, thus causing extreme variations in the test data recorded, according to Boeing personnel.

PROCEDURE:

The test program utilized the NBS Radiant Panel Apparatus as per Federal Standard No. 00136 (and/or ASTM E-162). Description of the test apparatus and procedures together with a definition of the measurements and units in the table headings are the same as those contained in Report NA-68-30.

DISCUSSION:

A list of 19 materials comprising 22 different specimens are listed and described in Table I. Radiant panel flammability data for the test specimens are given in Table II. A comparison of the flame-spread indices obtained by NAFEC, National Bureau of Standards (NBS) and the Dupont Co. on polycarbonates specimens of different thicknesses and one wool rug. A new type of honeycomb sheet assembly with a Nomex core instead of paper (No. 224) yielded an extremely low flame-spread index to show the superiority of this construction.

The ability of a highly reflective chrome film to protect a plastic underlay (No. 214) from radiant heat was demonstrated by the very low index and combustion obtained in the Radiant Panel tests.

The two materials chosen for the round-robin tests were selected by Boeing test personnel as the materials presenting particular difficulty for obtaining good repeatability of data. It was decided that the use of a finer screen to support the specimen should improve the tests. The results displayed in Table III show very good agreement for polycarbonate sheet, with the spread in the data about as large within each laboratory as between various laboratories for different specimens of the same material. Considerable variation in the data occurred for the wool rug tests with Dupont's flame-spread indices not only considerably lower, but also more consistent than those obtained by NBS or NAFEC. Some of the variation in the data, it is believed, resulted from the minor variation in the test method employed. Better uniformity in the NAFEC tests was obtained when the rug was backed-up by an air space. Since most aircraft cabin materials are unsupported, all materials have been tested in this manner.

SUMMARY OF RESULTS:

1. Additional Radiant Panel tests and contacts with industry further confirm that a requirement for a flame-spread index of 25/50 for all material applications in cabins except seat padding is attainable as shown in Table II within the present state-of-the-art technology.

2. Repeatability of Radiant Panel test data as shown in Table II between various laboratories is satisfactory and as good as can be expected in view of the complex nature of the fire propagation and the lack of better reproducibility of data within each series of tests by the same person.

Except for two foam plastics, all materials exhibited relatively low flame-spread indices, which in most instances were less than 50, with 11 materials, or close to one-half of all materials tested, with indices of less than 25. The latter figure has been a desirable goal to pursue as a standard since this corresponds to a Underwriter's designation of Class A fire rating.

Polyurethane seat foam, because of its very wide and extensive use in cabin furnishings, presents the greatest single deficiency relative to minimum safeguards to fire of any of the materials considered. Although flame-retardant varieties of this foam have been developed to make the basic polymer self-extinguishing, the flame-spread and heat of combustion values of the foam continue to be considered as relatively high and excessive. For example, the latest type of such foam (No. 213) shows a flame-spread index of 316, nevertheless, a considerable improvement over earlier FR urethane foams. Neoprene foam (No. 223) produced a much lower index than that for the urethane foam which is within range of the index criteria of 25. However, this material cannot as yet compete on a weight basis with urethane foam. Dupont estimates the weight penalty as still being about 2 to 1 over that of conventional foam for the same cushioning performance. The test results show an index of 26 for this material. According to Dupont, this foam material in the Underwriter's Laboratory (U.L.) 25-foot tunnel test showed an index of only 25 which further demonstrates the equivalence of the two methods. The material is being used in the padding of institutional carpets which are required by regulation to show an index of less than 75 by the U.L. tunnel test.

Two samples of wool rugs were tested. One was obtained from Boeing and the other from a carpet manufacturer. The rug furnished by the manufacturer, due to its more fire-resistant backing construction, produced a flame-spread index of better than 25. In the past only rugs of Nomex construction could regularly meet this criteria.

Of the various types of thermoplastics tested, polysulfone (No. 230) exhibited the lowest flame-spread index.

TABLE I

MATERIALS DESCRIPTION

Code	Thickness (in.)	Weight ($oz/yd.^2$)	Color and Surface	Designation	Inten
F-2	.0035	2.9	Gray	Fabric (C)	Insul cover
S-3	.025	26	Off White Smooth	Sheet (R)	Panel
S-1	.175	52	Yellow Smooth	Foam (F)	Paddi
S-2	.012	10	White Brushed	Sheet (SR)	Panel
S-2	.016	13	White Brushed	Sheet (SR)	Panel
S-3	.037	56	Lt.Green Smooth	Sheet (R)	Bagga
R-1	.25	60	Loop	Rug (UP)	Floor
S-3	.030 .060 .125	27 53 105	Clear Smooth	Sheet (R)	Windo Fabri
S-1	4.0	104	White Open cell	Foam (F)	Seat
S-3	.065	68	Mirror Shiny	Sheet (R)	Fabri galle
S-3	1.0	12	White Fine grain	Foam (R)	Insul

TABLE I

MATERIALS DESCRIPTION

Code	Thickness (in.)	Weight ($oz/yd.^2$)	Color and Surface	Designation	Intend
F-1	.030	9	Brown	Fabric (UC)	Uphols
S-3	.040	72	White Gold Embossed	Sheet (R)	Sidewa Bulkhe
S-3	.070	69	Lt. gray White Embossed	Sheet (R)	Sidewa Bulkhe
S-1	4.0	212	Lt. Brown Open cell	Foam (F)	Seat P
S-3	.54	44	White Matte	Honeycomb(R)	Partit
R-1	.25	59	Blue/Black Loop	Rug (UP)	Floori
S-3	.062	58	White Smooth	Sheet (R)	Paneli Moldin
S-3	.080 .030	82 28	White Smooth	Sheet (R)	Fabric parts

EVIATIONS:

F1, F2 - Uncoated and coated fabric
R1, R2 - Unpadded and padded rug
S1, S2, S3 - Flexible, semi-rigid and rigid sheet
L1, L2, L3 - Flexible, semi-rigid and rigid sheet
FR - Fire retardant treated

TABLE II

NEW MATERIALS
FLAMMABILITY DATA BY NBS RADIANT PANEL APPARATUS
FEDERAL STANDARD - TEST METHOD NO. 00136b (ASTM E-162)

Material No.	Code	Ignition Time (min)	Total Flaming Time (min)	Max Flame Propagation (in.)	Glow Time (min)	Total Burning Time (min)	Char Length (in.)	Max Temperature Rise (°C)	Fs Flame-Spread Factor	Is Flame-Spread Index	General Remarks
204	F2	0.01	0.43	6	0.0	5.00	15-17	10	30.2	40	Heavy white smoke reducing to trace white acrid smoke. Moderate flames.
204		0.01	0.29	5	0.0	5.00	15-17	6	17.7	14	
204		0.01	0.39	6	0.0	5.00	15-17	6	28.8	23	
Avg.		0.01	0.37	6	0.0	5.00	15-17	7	25.6	26	
205	S2	0.02	2.38	11	0.0	5.00	15-17	35	8.1	38	Heavy gray very sooty and very acrid smoke. Pilot snuffed out several times.
205		0.02	3.06	11	0.0	5.00	15-17	30	7.2	28	
Avg.		0.02	2.72	11	0.0	5.00	15-17	33	7.7	33	
206	S1	0.01	1.33	X(1)	0.0	2.00	15-17	62	227	1850	Heavy gray, white extremely acrid smoke. Very high flames. Flashes.
208	S2	0.02	0.28	3	0.0	15.00	13	3	11.0	4	Heavy white very acrid smoke for 0.50 min. then light white very acrid smoke. Flashes to 12 in.
209	S2	0.03	0.09	1	0.0	15.00	12	3	1.0	4	Trace of white acrid smoke.

Notes:
(1) X - Burns completely.

Abbreviations:
F1, F2 - Uncoated and coated fabrics.
R1, R2 - Unpadded and padded rugs.
S1, S2, S3 - Flexible, semi-rigid and rigid sheet.
L1, L2, L3 - Flexible, semi-rigid and rigid laminate.
A - Assembly

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FLAMMABILITY DATA BY NBS RADIANT PANEL APPARATUS
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Material No.	Code	Ignition Time (min)	Total Flaming Time (min)	Max Flame Propagation (in.)	Glow Time (min)	Total Burning Time (min)	Char Length (in.)	Max Temperature Rise (°C)	Fs Flame-Spread Factor	Is Flame-Spread Index	General Remarks
210	S3	0.08	1.66	8	0.0	15.00	12	19	7.0	18	Very heavy and extremely acrid white smoke. Flashes. Air mask required at 3.50 min.
		0.08	1.72	9	0.0	15.00	12	18	9.0	21	
Avg.		0.08	1.69	9	0.0	15.00	12	19	8.0	20	
211	R1	0.03	10.37	8	0.0	15.00	15-17	43	4.6	26	Heavy gray acrid smoke. Moderate flames.
211		0.03	7.12	10	0.0	15.00	15-17	54	23.7	169	
211		0.03	7.37	10	0.0	15.00	15-17	42	7.4	84	Rug backing in contact with asbestos board over entire surface area.
211		0.03	8.47	10	0.0	10.00	15-17	48	5.6	35	
Avg.		0.03	8.33	9	0.0	14.00	15-17	47	10.3	78	
211	R1	0.02	6.00	11	0.0	15.00	15-17	57	5.7	43	Heavy gray acrid smoke. High flames.
211		0.02	8.48	12	0.0	15.00	15-17	63	5.8	48	Air gap of 1/2 in. behind rug backing.
211		0.03	8.57	11	0.0	15.00	15-17	57	5.8	44	
211		0.03	7.17	13	0.0	10.00	15-17	60	8.8	70	
Avg.		0.03	5.55	12	0.0	14.00	15-17	59	6.5	51	
212A	S3	0.03	5.47	14	0.0	15.00	15-17	24	6.2	20	Heavy gray, very sooty and acrid smoke.
212A		0.05	3.65	X	0.0	3.70	15-17	33	8.4	37	High flames.
212A		0.06	3.74	X	0.0	3.80	15-17	45	9.2	55	Flaming droplets.
212A		0.06	3.94	X	0.0	4.00	15-17	24	8.3	26	Specimen thickness - 0.030 in.
Avg.		0.05	4.20	X	0.0	6.60	15-17	31	8.0	34	
212B	S3	0.07	7.18	14	0.0	11.00	15-17	45	5.8	34	Heavy gray very sooty and acrid smoke.
212B		0.06	5.14	X	0.0	5.20	15-17	29	6.3	24	Flaming droplets.
212B		0.05	5.55	X	0.0	5.60	15-17	41	6.5	35	Specimen thickness - 0.060 in.
212B		0.05	5.30	X	0.0	5.35	15-17	28	6.7	25	
Avg.		0.06	5.79	X	0.0	6.79	15-17	36	6.3	29	

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Material No.	Code	Ignition Time (min)	Total Flaming Time (min)	Max Flame Propagation (in.)	Glow Time (min)	Total Burning Time (min)	Char Length (in.)	Max Temperature Rise (°C)	Fs Flame-Spread Factor	Is Flame-Spread Index	General Remarks
212C	S3	0.08	10.17	14	0.0	11.00	15-17	44	4.8	28	Heavy gray very sooty acrid smoke Flaming droplets. Specimen thickness - 0.125 in.
212C		0.06	7.94	X	0.0	8.00	15-17	54	5.1	36	
212C		0.07	7.25	X	0.0	7.32	15-17	37	5.2	26	
212C		0.10	10.40	13	0.0	15.00	15-17	32	4.6	20	
Avg.		0.08	10.44	14	0.0	10.33	15-17	42	4.9	28	
213	S1	0.01	0.68	X	0.0	0.69	15-17	43	55.5	315	Heavy white very sweet smoke. High flames. Droppings do not burn.
214B	S3	0.30	14.70	0	0.0	15.00	4	7	1.0	1	Light white smoke. Small flames emerge from hole in chrome plating. Surface metal separates from plastic filler but maintains protection for 15 minutes.
215	S3	0.03	1.00	0	0.0	15.00	9-13	12	1.0	2	Heavy white acrid smoke. Charring mostly on surface. All smoke and physical changes occurred in first 3 min.
215		0.03	1.37	4	0.0	15.00	9-13	17	2.4	5	
Avg.		0.03	1.18	2	0.0	15.00	9-13	15	1.7	4	
216	F1	0.09	0.63	3	13.5	15.00	10	18	2.8	7	Moderate white smoke.
218	L3	0.06	1.80	10	0.0	15.00	15-17	6	7.8	6	Light gray acrid smoke. Flashes. Flaming droplets appear to be the Tedlar coating.
219	L3	0.02	10.50	13	0.0	15.00	15-17	68	5.9	53	Heavy gray very acrid smoke. Very high gas flames.

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223	S3	0.01	1.00	4	5.0	10.00	15	18	8.7	21	Heavy white pungent smoke.
223		0.01	1.00	4	5.0	10.00	15	17	9.3	21	Charred residue powdery.
223		0.01	1.00	4	5.0	10.00	15	17	9.3	21	
Avg.		0.01	1.00	4	5.0	10.00	15	17	9.1	21	
224	L3	0.06	1.00	2	0.0	15.00	15	7	1.0	1	Surface char. Internal char 6-8 in.
224		0.08	1.00	2	0.0	15.00	15	5	1.0	1	Moderate to heavy white acrid smoke.
Avg.		0.07	1.00	2	0.0	15.00	15	6	1.0	1	Intumescent thickness to 3/8 in. Flashes 3-6 in.
226	R1	0.03	6.67	8	0.0	10.00	15-17	26	5.25	18	Moderate white pungent smoke.
226		0.03	5.27	10	0.0	10.00	15-17	33	5.87	26	Pilot snuffed out twice.
226		0.03	4.97	10	0.0	10.00	15-17	24	4.23	13	Material boils.
Avg.		0.03	5.64	9	0.0	10.00	15-17	28	5.12	19	
227	S3	0.04	6.46	12	0.0	10.00	13	85	6.80	76	Heavy gray sooty acrid smoke.
227		0.04	7.26	11	0.0	10.00	12	80	7.43	78	Very high flames. Flashes.
227		0.03	7.97	11	0.0	10.00	13	73	7.53	73	
Avg.		0.04	7.23	11	0.0	10.00	13	79	7.25	76	
230A	S3	0.06	7.84	13	0.0	10.00	14	36	4.25	20	Moderate gray sooty smoke with slight odor. Droplets burned on floor. Specimen thickness - 0.080 in.
230B	S3	0.14	2.34	10	0.0	10.00	11	7	4.22	4	Moderate sooty gray smoke with slight odor. Droplets burned on floor. Specimen thickness - 0.030 in.

TABLE III

RADIANT PANEL ROUND-ROBIN TESTS
REPEATABILITY OF FLAME-SPREAD INDEX DATA (Is)

(1) Laboratory	(2) Polycarbonate 30 mil No. 212A	Polycarbonate 60 mil No. 212B	Polycarbonate 125 mil No. 212C	(3) Wool Carpet No. 211	Hard-Board Standard
NBS	25	32	21	55	130
	27	28	25	104	128
	27	23	32	25	97
	26	19	27	75	96
Ave.	26	25	26	65	113
NAFEC	20	34	28	26	85
	37	24	36	169	106
	55	35	26	84	126
	26	25	20	35	96
Ave.	34	29	27	78	103
duPont	30	35	37	20	122
	23	25	36	19	120
	29	22	40	34	132
			43	29	123
Ave.	27	28	39	25	124
Boeing	(Data not available at this time)				

Notes: (1) Polycarbonate sheets and wool carpet materials supplied to participating laboratories by Boeing Company.

(2) A 1/4-inch instead of the normal 1-inch wire screen for supporting the test specimen was used because of excessive melting and dripping of polycarbonate sheets.

(3) Wool carpet placed in full contact with the surface of the asbestos board for test. No air gap provided as with polycarbonate sheet.